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Seasonal distribution and some biological parameters of the Caspian seal (*Pusa caspica)* in the southeastern region of the Caspian Sea

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Abstract

The Caspian seal (*Pusa caspica)* from Phocidae family is the only living mammal that exclusively inhabits the landlocked Caspian Sea. This study was first of its kind conducted on the Caspian seals in the southeastern region of the Caspian Sea from 2010 to 2016. Seasonal observations, gender, maturity, biometric parameters and condition index of each observed Caspian seal were studied. Totally 74 live Caspian seals including 42 males and 32 females were observed in this study. The Caspian seals observed in autumn were significantly greater in number than in the other seasons (p<0.05). There was no significant difference between the number of the males and females (p>0.05), however, the number of juvenile seals were significantly more than adults (p<0.05). This study revealed no significant difference in each biometric parameter and condition index in different seasons, and also between female and male Caspian seals (p>0.05). A significant difference was observed between adult and juvenile seals in biometric parameters (p<0.05), however condition index was not significantly different (p>0.05). Since Caspian seals are listed as endangered species in the IUCN Red List, further research is required to understand the status of this population and conserve the only mammals of the Caspian Sea.

Keywords: *Pusa caspica,* Caspian Sea, Biometric parameters, Condition index

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Introduction

The Caspian Sea is the largest body of water enclosed on land which is divided along the north-south axis into three regions; the north, middle and south basins surrounded by Russia, Kazakhstan, Azerbaijan, Turkmenistan and Iran (Kostianoy and Kosarev, 2005).

Various species of organisms including phytoplanktons, zooplanktons and fishes live in the Caspian Sea, but the only living mammal exclusively inhabiting the Caspian Sea is the Caspian seal (*Pusa caspica)* from Phocidae family (Sharipov, 2012). *P. caspica* has regular migrations from the north part to the deep waters of the south Caspian Sea (Perrin *et al*., 2009; Dmitrieva *et al*., 2016).

Marine mammals are often recognized as an indicator of health in marine ecosystems (Olsson *et al*. 1994; Kannan *et al*., 2000). *P. caspica* has always been threatened by various factors in the Caspian Sea. One of the treats to Caspian seals are pups hunting that can be one of the reasons for the significant decrease of Caspian seal populations (Harkonen *et al*., 2008; Harkonen *et al*., 2012; Sharipov, 2012). Environmental pollution such as the irregular entry of agricultural pesticides, heavy metals and microbes are the factors causing adverse effects and mortality in the population of Caspian Sea (Kennedy *et al*., 2000; Eybatov *et al*., 2002; Kajiwara *et al*., 2008; Wilson *et al.*, 2014). Studies revealed organochlorines and heavy metals have led to infertility and reduction of reproduction in Caspian seals (Kliks *et al*., 1997; Reijnders, 2003). Food shortage is another threatening factor for the Caspian seal. The main food of the Caspian seal is fish especially different species of kilka including common kilka (*Clupeonella cultriventris caspia*), anchovy kilka (*C. engrauliformis*), and bigeye kilka (*C. grimmi*) that have reduced since the control of the Volga River, ravage of the *Mnemiopsis leidyi* to the Caspian Sea, and overfishing (Pourang *et al*., 2016). Trapping of the seals in fishing nets particularly sturgeon net has caused mortality of thousands of seals in different parts of the Caspian Sea and is considered as another threatening factor to the Caspian seal (Dmitrieva *et al*., 2011; Harkonen *et al*., 2012). Climate alteration causing decrease of ice masses in breeding regions in the northern Caspian Sea is considered as habitat variation and the other reason for seal population reduction (Sharipov, 2012).

The number of Caspian seals decreased from about one million in the early 20th century to 360,000–400,000 in the 1980s (Krylov, 1990), and to about 100,000 in 2005 (Harkonen *et al*., 2008). The total number of pups in the North part of the Caspian Sea was estimated as 21,000 in 2005 and 17,000 in 2006 (Harkonen *et al*., 2008). Therefore, International Union for Conservation of Nature (IUCN) Red List changed the status of the Caspian seal from "vulnerable" to "endangered"

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in October 2008 (Harkonen *et al*., 2008).

Regular monitoring of *P. caspica* in different part of the Caspian Sea, annual estimation of temporal and spatial observations, examination of cause of mortality and identification of safe places for seals are important and effective ways to conserve this endangered species.

The present study aimed to investigate the seasonal observation, biometric parameters and condition index of live Caspian seals observed from 2010 to 2016 in the southeastern region of the Caspian Sea.

Materials and methods

Study area and collection data

This study was carried out in the southeast region of the Caspian Sea with a coastline length of about 90 km from Miankaleh wetland (36°53'32.60"N, 53°40'0.93"E) to Iran-Turkmenistan border (37°19'28.48"N, 53°54'19.22"E) (Fig. 1) from January of 2010 to December of 2016.

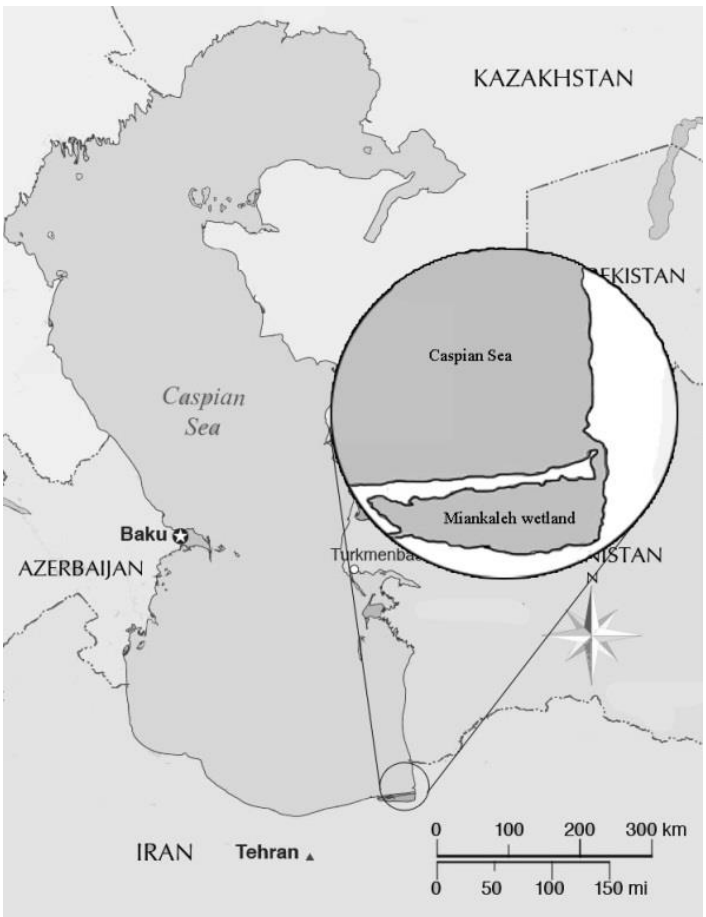

Figure 1: Map of the study area in the present study.

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In the present study, the date and geographic location of each observed live Caspian seal was recorded. In order to determine gender, maturity status and measurement of biometric parameters, each live Caspian seal was transferred to the Caspian Seal Rehabilitation and Research Center in Ashoorade Island, Golestan Province in Iran.

In female seals, the breasts are around the umbilicus and the vulva is near the anus, however, in males the penis is close to the umbilicus and the testicles are inguinal (Le Boeuf, 1991).

Biometric parameters including total length (nose to the end of back flippers), standard length (nose to the end of the tail), girth (around the chest between the front flippers) (Wilson *et al*., 2014) and, also condition index (100×girth/standard length) (McLaren, 1958) of each Caspian seal were measured.

Statistical analysis

The normality of the data was evaluated using Kolmogorov-Smirnov test. The generalized linear model with Poisson distribution was used to analyze the number of observed Caspian seal by gender (male and female), maturity (adult and juvenile), in terms of different seasons, separately. An independent sample T test evaluated the effect of gender and maturity on biometric parameters and condition index, separately. Also, the effect of different seasons was analyzed by one-way way ANOVA and Duncan's post hoc multiple comparison test. Pearson correlation test and linear regression test based on the regression formula "$y = \alpha + \beta x$" were used to analyze the relationship of different biometric parameters and condition index of the male and female Caspian seals. The statistical analysis was performed using SPSS22.

Results

Number of observed Caspian seals

The result of the present study revealed that totally 74 live Caspian seals including 42 males and 32 females were observed. The statistical analysis showed that the number of Caspian seals observed in autumn were significantly more than that in other seasons ($p<0.05$). There was no significant difference between the number of the males and females ($p>0.05$). However, the number of juvenile seals was significantly more than adults ($p<0.05$). The numbers of male and female, adult and juvenile Caspian seals from 2010 to 2016, and in different seasons are shown in " Table 1 and 2", ", respectively.

Biometric parameters and condition index of the observed Caspian seals

The result of this study indicated that there were no significant difference in each of the biometric parameters and condition index in different seasons ($p>0.05$) (Table 3).

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Table 1: The number of observed Caspian seals in the present study during 2010 to 2016. ND: not determined.

Season	Juvenile		Adult		ND		Total
	Male	Female	Male	Female	Male	Female	
2010	3	1	1	1	1	0	7
2011	5	4	2	2	0	0	13
2012	4	1	2	2	1	0	10
2013	4	6	2	0	0	0	12
2014	5	3	1	0	0	0	9
2015	7	6	1	1	0	1	16
2016	2	3	0	1	1	0	7
Total	30	24	9	7	3	1	74

Table 2: The number of observed Caspian seals including male, female, adult and juvenile in different seasons in the present study. ND: not determined.

Season	Juvenile		Adult		ND		Total
	Male	Female	Male	Female	Male	Female	
Spring	10	6	1	3	2	0	22
Summer	1	0	1	1	0	0	3
Autumn	19	15	7	3	1	1	46
Winter	0	3	0	0	0	0	3
Total	30	24	9	7	3	1	74

Also, as seen in "Table 4" there was no significant difference between female and male Caspian seals regarding to biometric parameters and condition index analysis ($p>0.05$).

In relation to adult and juvenile Caspian seals, a significant difference was observed in each biometric parameter ($p<0.05$), however condition index was not significantly different ($p>0.05$) (Table 5). It is noteworthy that 4 Caspian seals including 3 males and 1 female were released into the Caspian Sea and therefore, maturity and biometric determination were examined in only 70 Caspian seals (Tables 1 and 2).

Correlation and regression relationship of the biometric parameters and condition index

The results showed a strong significant positive correlation between total length and girth, standard length and girth, as well as between condition index and girth in both male and female Caspian seals ($p<0.01$). Moreover, negative correlation was observed between total length and condition index in males and females ($p>0.05$), which was significant in females ($p<0.05$). Regression relationship of biometric parameters and condition index is presented in "Fig. 2".

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Table 3: Mean±SD (cm) of biometric parameters and condition index of Caspian seals (n=70) in different seasons in the present study (different letters above the numbers indicate significant differences in each column (p<0.05)).

Season	Total length	Standard length	Girth	Condition index
Spring	114.65±7.4[a]	102±6.65[a]	87.35±8.76[a]	85.59±5.74[a]
Summer	113.33±7.5 [a]	102.67±10.01[a]	91.33±9.5 [a]	88.92±0.65[a]
Autumn	113.23±13.55 [a]	101.75±12.16[a]	91.57±13.36[a]	90.26±10.08[a]
Winter	115.33±9.81 [a]	102.33±9.04 [a]	90.33±4.04[a]	88.81±12.39[a]

Table 4: Mean±SD (cm) of biometric parameters and condition index in the male (n=39) and female (n=31) Caspian seals in the present study (different letters above the numbers indicate significant differences in each column (p<0.05)).

Gender	Total length	Standard length	Girth	Condition index
Male	113.54±12.13[a]	102.03±10.85[a]	89.1±12.69[a]	87.36±831[a]
Female	113.97±11.08[a]	101.71±10.15[a]	91.81±10.57[a]	90.64±9.65[a]

Table 5: Mean±SD (cm) of biometric parameters and condition index of the adult (n=16) and juvenile (n=54) Caspian seals in the present study (different letters above the numbers indicate significant differences in each column (p<0.05)).

Maturity	Total length	Standard length	Girth	Condition index
Adult	127.44±8.47[a]	115.06±8.38 [a]	104.25±11.21[a]	90.45±4.5[a]
Juvenile	109.67±9.01[b]	97.98±7.42[b]	86.17±8.33 [b]	88.33±9.95[a]

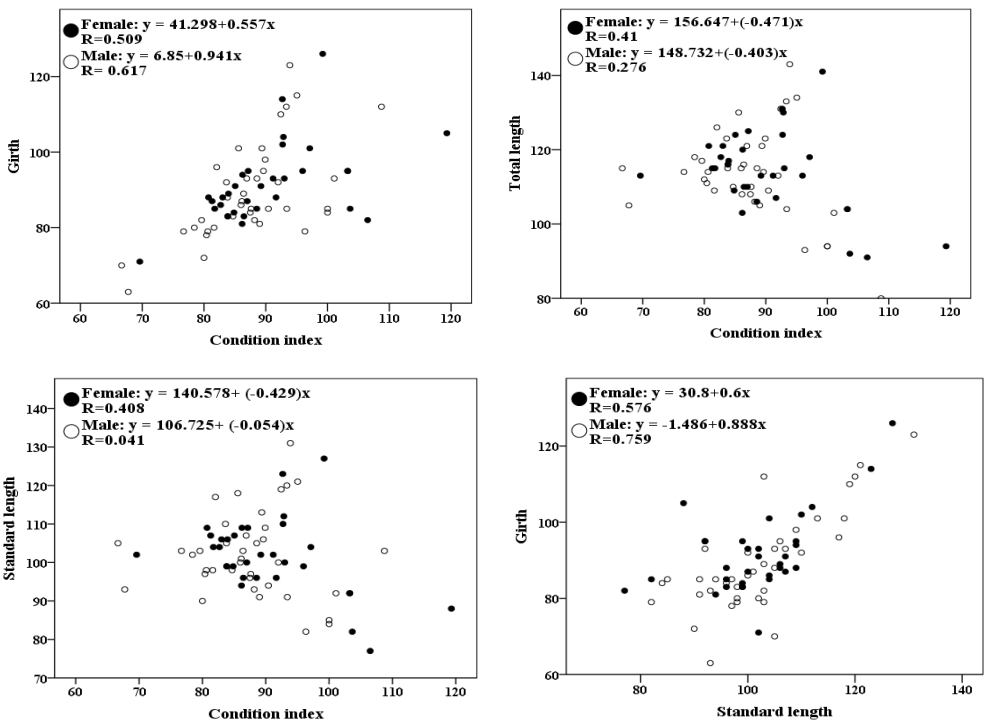

Figure 2: Regression relationship of biometric parameters and condition index in male and female Caspian seals in the present study.

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Discussion

Caspian seals gather in the north of the Caspian Sea in winter, because the pups should be born on steady ice (Le Boeuf, 1991; Perrin *et al*., 2009).The reproductive cycle of Caspian seals which is associated with seasonal changes is regulated by changes in hormonal levels. Breeding, giving birth, lactation and molting happen in late winter and early spring in the north part of Caspian Sea and cause weight loss in seals (Ryg *et al*., 1990). After molting, seals migrate to the southern parts of the Caspian Sea to find food; consequently, they have a better condition index in autumn (Dmitrieva *et al*., 2016). The Caspian seals migrate back to the north in the late autumn for breeding, however a number of juvenile seals still remain in the southern part (Dmitrieva *et al*., 2016).

In the present study, the number of Caspian seals observed in autumn was significantly more than in other seasons. Studies revealed temporal observation of Caspian seal is consistent with their migration. Reports of the Caspian Environment Program (2010) indicated the mortality rate of Caspian seals increased on the coast of Azerbaijan when the seals migrate to the north of the Caspian Sea in autumn. The carcasses and seals trapped in fishing nets were mainly observed in autumn on the coast of Iran (Mirzajani and Karami, 2000).

Also, according to seal observation in the Caspian Sea, it can be concluded that the migration of seals is associated with the distribution of the bony fish especially kilka. Biological living depth of many fish varies in different seasons of the year. Anchovy kilka (*C. engrauliformis*) is distributed in the middle and southern part of the Caspian Sea. This species stays under the warm water of the surface during the summer, and passes through the seasonal thermocline where nutritional sources are located (Aseinova, 1994; Fazli *et al*., 2007). Most Anchovy kilka can tolerate salinities only between 10-12 ppt (Karimzadeh *et al*., 2010). Common kilka (*C. cultriventris caspia*) lives in coastal zone with the greatest distribution in the southern part of the Caspian Sea (Fazli *et al*., 2007). Common kilka is a euryhaline species that can tolerate freshwater of salinity more than 36 ppt (Karimzadeh *et al*., 2010). Bigeye Kilka (*C. grimmi*) inhabits in the middle and southern part of the Caspian Sea and moves from the southern Caspian Sea to the middle Caspian Sea during the spring and summer, and then migrates back to the southern Caspian in autumn (Janbaz *et al*., 2016). The highest kilka biomass in the Caspian Sea belonged to anchovy kilka, however, the usual distribution of these three kilka species has changed obviously over the past decades. One of the reasons is the change of the hydrological regime in the Caspian Sea that is preferred by the common kilka, but is not optimal for anchovy kilka (Mamedov, 2006).

Kilka fishes are the major nutritional source of Caspian Sea for piscivorous species such as Caspian seals (Karimzadeh *et al*., 2010). However,

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overfishing and invasion of *Mnemiopsis leidyi* has reduced the total kilka population (Mamedov, 2006) and caused Caspian seal to feed on other species such as Caspian silverside, gobies and crustaceans as alternative food instead of kilka (Miyazaki, 2001). As a result, the collapse of the food chain has caused population reduction of many species inhabiting in the Caspian Sea.

A review of the literature indicated that limited studies have been conducted on Caspian seal distribution in Iranian waters of the Caspian Sea. In the study of Asadi (2001) a total of 58 carcasses of Caspian seals were observed along 28 km of Caspian Sea coastline in Guilan Province. Mirzajani and Karami (2000) detected 29 carcasses of Caspian seals in the coast of Anzali in Guilan Province from 1995 to 1999. There are some other studies which have been performed on various contaminants in Caspian Sea such as polyaromatic hydrocarbons (Esmaili *et al*, 2002), chlorinated hydrocarbons (Vetted *et al*., 1995), parasite (Amin *et al*., 2011) and virus (Wilson *et al*., 2014).

Thus, the present study is the first investigation on seasonal observation and some biological parameters of the Caspian seal in the southeastern part of the Caspian Sea from Miankaleh wetland to the Iran-Turkmenistan border.

In the recent years, Caspian Seal Rehabilitation and Research Center has performed remarkable measures in order to conserve the Caspian seal in Iran, particularly with regard to training the fishermen about appropriate encounters with Caspian seals. Note that all Caspian seals in this study were live and referred by fishermen that cooperated with the Caspian Seal Rehabilitation and Research Center. Caspian Seals are kept and treated at the Caspian Seal Rehabilitation and Research center, and then they are released to the Caspian Sea to survive.
Eventually, it must be emphasized that further research and more concern in relation to Caspian seals is necessary to understand the status of the Caspian seal population and conserve this endangered species.

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